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PROBLEM STATEMENT NO:
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## STAGE I RESEARCH PROBLEM STATEMENT

### I. PROBLEM TITLE:

**Steel Pipe Pile/Concrete Pile Cap Bridge Support Systems: Confirmation of Connection Performance**

### II. PROBLEM STATEMENT:

The Montana Department of Transportation (MDT) has found steel pipe piles connected at the top by a concrete pile cap to be a very cost effective support system for short and medium span bridges. This type of system offers low initial cost, short construction time, low maintenance requirements, and a long service life. From a structural engineering perspective, these systems must provide acceptable performance under gravity (i.e., self weight and vehicle loads) and lateral loads (i.e., extreme ice, wind, and seismic events). While the gravity load performance of these systems is well understood, their strength and ductility under extreme lateral loads is more difficult to reliably predict using conventional design procedures. Therefore, MDT sponsored a research project at Montana State University (MSU) to investigate the performance of these systems under extreme lateral loads (this project was completed in 2005). As part of this investigation, MSU conducted five physical tests on 1/2-size models of the pipe pile to steel pile cap connection. The models were designed to replicate the behavior of full-size connections under reversed seismic loads. Four different reinforcing schemes within the connection zone were evaluated.

Based on the results of the tests conducted at MSU, in conjunction with established structural engineering principles, MDT developed a new design procedure to determine the reinforcing steel required in the pile cap to produce the desired system performance under extreme lateral loads. While the layout of the reinforcing steel generated by this design procedure is generally similar to the layout that was evaluated in the final pile cap test, there are several differences between the reinforcing configuration that was tested and what the design procedure generates. Additionally, in the design procedure, there is an alternate and somewhat simpler arrangement of the reinforcement that offers some advantages relative the constructability of the pile cap, and this alternate arrangement has not been tested.

MSU still has the load frame and other equipment used in the earlier pile cap research project. This equipment can readily be used to more fully validate the performance of the connection designs produced by the new design procedure.

### III. RESEARCH PROPOSED:

This research effort will consist of testing selected 1/2-size models of pipe pile to concrete pile cap connections designed following MDT's new connection design procedure. Prior to conducting these tests, a literature review will be done to identify any research that has been performed on this subject since MSU's most recent project (completed in 2005). Following this review, the specific connection configurations to be tested in this effort will be determined by MDT (in consultation with MSU as appropriate). Testing will be done under fully-reversed, simulated seismic loads using equipment and procedures developed by MSU for this purpose in the earlier pile cap research project. Lateral load, deflection, and selected internal strains will be measured during these tests to evaluate connection capacity and ductility. Revisions to the design procedure used for these connections will be made as appropriate based on the literature review and test results.

### IV. IT COMPONENT:

The work proposed herein does not require IT hardware, software or support.

## V. URGENCY AND EXPECTED BENEFITS:

Bridges have been found to be a particularly vulnerable element of critical infrastructure systems during earthquakes. While steel pipe pile/concrete pile cap bridge support systems designed following the new procedure developed by MDT offer significantly better performance in seismic events than those designed using older methodologies, this design procedure has not been fully validated by physical testing. The results of this project will provide such validation, or the data necessary to revise this new procedure, so that the required connection performance during seismic events is realized.

## VI. IMPLEMENTATION PLAN:

Based on the literature review and test results, modifications will be suggested and made as necessary to the design procedure for steel pipe pile to concrete pile cap connections.

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